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भाग 1 सामान्य अपेक्षाएँ

Indian Standard

RADIATION MONITORING EQUIPMENT FOR ACCIDENT AND POST-ACCIDENT CONDITIONS IN NUCLEAR POWER PLANTS

PART 1 GENERAL REQUIREMENTS

ICS 27.120.20

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

February 1998

Price Group 11

Nuclear Instrumentation Sectional Committee, LTD 26

NATIONAL FOREWORD

This Indian Standard which is identical with IEC 951-1 (1988) 'Radiation monitoring equipment for accident and post-accident conditions in nuclear power plants — Part 1 : General requirements' issued by the International Electrotechnical Commission (IEC), was adopted by the Bureau of Indian Standards on the recommendations of Nuclear Instrumentation Sectional Committee, LTD 26, and approval of the Electronics and Telecommunication Division Council.

In the adopted standard, certain terminologies and conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following.

Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

CROSS REFERENCES

In this standard, the following International Standards are reffered to. Read in their places, the following :

International Standard	*Indian Standard*	*Degree of Equivalence*
IEC 50 (391) (1975) International Electrotechnical Vocabulary Ch. 391 : Detection and measurement of ionizing radiation by electric means	IS 1885 (Part 63) : 1985 Electrotechnical vocabulary : Part 63 Nuclear instrumentation	Technically Equivalent
IEC 181 (1964) Index of electrical measuring apparatus used in connection with ionizing radiation	IS 11600 : 1985 Index of electrical measuring apparatus used in connection with ionizing radiation	do

The technical committee responsible for the preparation of this standard has reviewed the provisions of the following international publications and has decided that they are acceptable for use in connection with this standard :

IEC 50 (392) (1976)	Ch. 392 : Nuclear instrumentation — Supplement to Chapter 391
IEC 278 (1968)	Documentation to be supplied with electronic measuring apparatus
IEC 293 (1968)	Supply voltages for transistorised nuclear instruments
IEC 557 (1982)	IEC terminology in the nuclear reactor field
IEC 654-1 (1993)	Industrial process measurement and control equipment — Operating conditions — Part 1 : Climatic conditions
IEC 780 (1984)	Qualification of electrical items of safety system for nuclear power generating stations
IEC 801-1 (1984)	Electromagnetic compatibility for industrial process measurement and control equipment — Part 1 : General introduction

Only English language text in the IEC publication has been retained while adopting this standard.

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Indian Standard

RADIATION MONITORING EQUIPMENT FOR ACCIDENT AND POST-ACCIDENT CONDITIONS IN NUCLEAR POWER PLANTS

PART 1 GENERAL REQUIREMENTS

CHAPTER I: GENERAL

1 Scope

This standard provides guidance on the design principles and performance criteria for equipment to measure radiation and fluid (gases or liquids) radioactivity levels at reactor plants during and following an accident. Such equipment is provided to meet the requirements of the responsible regulatory authorities and as appropriate to the design of the particular reactor plant and systems. This standard, therefore, is to be read in conjunction with national requirements which may modify the principles, details or parameters included.

This standard is limited to equipment for on-site radiation monitoring and fluid stream radioactivity monitoring during and after an accident (including any long-term shutdown phase). This part of the standard deals with the general principles and design requirements for such equipment; additional details for particular types of monitors* will be given in subsequent parts of the standard (as they are published), which will be consulted in conjunction with this part.

2 Object

The object of this standard is to lay down general requirements and give examples of acceptable methods for monitoring radiation and fluid radioactivity levels during and after an accident.

It specifies, for the equipment described in the scope, the general design and performance characteristics, general test procedures, radiation, electrical, safety and environmental characteristics and the documentation required.

3 Terminology and units

3.1 *General terminology*

The general terminology concerning detection and measurement of ionizing radiation and nuclear instrumentation is given in the following IEC publications:

- 50(391) (1975): International Electrotechnical Vocabulary (IEV), Chapter 391: Detection and measurement of ionizing radiation by electric means.
- 50(392) (1976): Chapter 392: Nuclear instrumentation - Supplement to Chapter 391.
- 181 (1964): Index of electrical measuring apparatus used in connection with ionizing radiation.

Additional terms concerning radiation protection will be given in IEC XXX (in preparation).

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* For example: high range gamma radiation monitors; process stream monitors; effluent monitors.

3.2 *Accident monitor*

In this standard, accident monitor is equipment intended for monitoring radiation or radioactivity levels in fluids in a reactor plant during or after an accident (refer to 2.1 of IEC 557, for definition of accident conditions).

The different parts of the equipment may conveniently be grouped into two assemblies which may be associated or separated according to the monitoring and operating requirements and equipment design.

3.2.1 *Detection assembly or sampling and detection assembly*

An assembly including one or more radiation detectors and associated sub-assemblies or basic function units.

3.2.2 *Control and measurement assembly*

An assembly including sub-assemblies and function units designed to measure quantities connected with ionizing radiation (activity, dose, dose rate, etc.). The assembly is provided with function units for giving an alarm signal when the quantity being measured exceeds some predetermined value.

3.3 *Conventionally true activity, dose, dose rate*

The best estimate of the value of activity of radioactive sources, doses or dose rates used for calibration of equipment; this value and its uncertainty shall be determined from a primary or secondary standard, or by a reference instrument which has been calibrated against a primary or secondary standard.

3.4 *Indicated activity, dose, dose rate*

The activity, dose or dose rate indicated by the measuring assembly under test.

3.5 *Coefficient of variation*

The ratio V of the standard deviation s to the arithmetic mean $\bar{x}$ of a set of n observed measurements x_i given by the following formula:

$$V = \frac{s}{\bar{x}} = \frac{1}{\bar{x}} \sqrt{\frac{1}{n-1} \sum_{1}^{n} (x_i - \bar{x})^2}$$

3.6 *Minimum detectable activity*

The activity which will give a mean indication such that in the presence of a specified background there is a 95% probability that such an indication will not be produced by the specified background alone.

3.7 *Error of indication*

The difference between the indicated dose (rate) or activity and the conventionally true dose (rate) or activity at the point of measurement.

3.8 *Relative error of indication*

The quotient, expressed as a percentage, of the error of indication by the conventionally true dose (rate) or activity.

3.9 *Relative intrinsic error*

The relative error of indication of an assembly with respect to a specified dose (rate) or activity under specified reference conditions.

3.10 *Effective range of measurement*

The range of measurement within which the requirements of this standard are met.

3.11 *Response time*

The time delay between initial exposure of the detection assembly to a given dose (rate) or activity and the attainment of 90% of the equilibrium reading or for integrating monitors, 90% of the equilibrium value of the first derivative of the indication with respect to time.

> *NOTE* - This definition may not be directly applicable to digital instruments, where the response time can be taken to be twice the basic data sampling interval, unless there is a physical delay time related to sample collection/transport.

3.12 *Units*

This standard uses the SI system of units*. For radiation quantities, the values expressed in units in temporary use (curie, rad, rem) are also indicated in brackets. The following units of practical importance may also be used where appropriate:

- for time: years, days, hours, minutes;
- for energy : electronvolt.

3.13 *Reference response*

The reference response R_{ref} is the response of the assembly under standard test conditions (Table I) to unit reference dose (rate) or activity and is expressed as:

$$R_{ref} = \frac{I_{rs} - I_{sb}}{S_{rs}}$$

where :

I_{rs} = indication due to reference source and radiation background
I_{sb} = indication due to radiation background
S_{rs} = reference dose (rate) or source strength

3.14 *Qualification tests*

Qualification tests are defined as tests performed in order to verify that the requirements of a specification are fulfilled.

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* Bureau international des poids et mesures: Système international d'unités (SI) (third edition [1977]).

The term "qualification" has acquired a special usage in the field of safety-related equipment in nuclear reactor power plants. See, for example, IEC 780.

Nevertheless, in this standard, the terminology defined in the IEV is used.

Qualification tests are subdivided into type tests, routine tests and acceptance tests.

3.14.1 *Type test (IEV 151-04-15)*

Tests of one or more devices made to a certain design to show that the design meets certain specifications.

3.14.2 *Routine test (IEV 151-04-16)*

Tests to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria.

3.14.3 *Acceptance test (IEV 151-04-20)*

A contractual test to prove to the purchaser that the device meets certain conditions of its specification.

3.14.4 *Commissioning test*

A test on a device or equipment, carried out on site, to prove the correctness of installation and operation.

NOTE - For this test, the equipment has to be installed and connected to all associated equipment necessary for its intended function on site.

3.15 *Manufacturer and purchaser*

The term "manufacturer" includes the designer of the equipment. The term "purchaser" includes the user of the equipment.

CHAPTER II: EQUIPMENT DESIGN

4 General

The primary purpose of accident monitors is to provide information to the plant operators which will assist them in taking appropriate actions to minimize damage to the plant, hazards to operators and consequences to the environment during and following an accident. These monitors may also provide information which will facilitate an assessment of the consequences of any release of activity to the environment or assist in investigation of the cause and progress of the accident.

The number and types of accident monitoring equipment are dependent on the detailed plant design, the plant accident analyses and the requirements of the responsible regulatory authority.

In all cases, however, it is essential to establish that the range of measurements and the environmental conditions for which the accident monitors are designed adequately encompass the accident and post-accident conditions for which the monitors are intended to function, including extended post-accident operation .

To meet the requirements of this standard, it may not be necessary to provide additional equipment to that intended for routine monitoring. An acceptable alternative may be to upgrade and qualify routine monitoring equipment to satisfy the requirements for accident and post-accident monitoring. However, it is important that such upgrades do not adversely affect normal operation performance. In such cases, appropriate precautions shall be taken to ensure that the required function is not degraded by failures of associated normal operation equipment.

Additional requirements may also arise from association with other systems. Monitors may be associated with the reactor protection system and would then need to conform to relevant IEC requirements. Monitors may also be required to interface with computer equipment, both sending and receiving relevant information.

NOTE - The necessary design parameters are the joint responsibility of the equipment manufacturer and the plant designer. The plant designer is responsible for defining the parameters appropriate for the reactor design and safety case. The manufacturer is responsible for ensuring that the monitor design is adequate to meet the agreed requirements.

5 Parameters to be monitored

As already indicated, the extent and design of accident monitoring is dependent on plant design, safety assessments and national regulatory requirements.

Other parts of the standard dealing with particular types of measurement (see clause 1) give more detailed guidance.

6 Location and environmental conditions

Within the overall constraint that equipment shall be located as appropriate to the parameter being measured, it is to be expected that equipment locations will be chosen to minimize the extremity of conditions to which the monitors will be exposed. Nevertheless, during and after an accident, at least parts of the equipment will require to be designed for extreme environmental conditions (e.g. detection assemblies and interconnecting cables inside a primary containment would be subject to high temperatures, pressures and humidity) and these shall be specified by the plant designer.

As far as is practicable, control and measurement assemblies will be located in reasonably controlled environments and equipment designs shall therefore be such as to allow the control and measurement assembly to be mounted remote from the detection assembly; the distances involved will depend on the application but may be up to several hundred meters. The actual cable lengths shall be specified in accordance with the requirements of the equipment function. Some essential equipment may require to be qualified for seismic conditions and the plant designer shall specify the requirements, including assumed seismic levels, for such equipment.

7 Identification of design parameters

Bearing in mind the factors discussed in clause 5 and the wide range of requirements existing for accident monitors, it is not reasonable to provide a comprehensive recommendation for every possible specific monitor equipment.

Nevertheless, for each monitor, at least the following design requirements shall be identified:

a) range of radiation parameter to be monitored;
b) accuracy of the measurement;
c) response time;
d) time interval during which the measurement is needed;
e) local environmental conditions in which the different components of the monitor have to operate ;
f) form of information display (e.g. specific activity, dose rate, integrated dose, etc.);
g) the extent of digital and/or analogue signal transmission to remote locations such as the control room (where the signals may be used as an input to a comprehensive data processing system);
h) spatial distribution of sensors;
i) appropriate energy response of detector in relation to expected radiation energy spectrum;
j) safety classification;
k) necessary man/machine interaction (e.g. design provisions to facilitate repair and maintenance, clarity of display, avoidance of anomalous indications).

8 Measurement characteristics

8.1 *Range of measurement*

The range of measurement of the equipment shall be appropriate to the particular application and be specified by the plant designer taking account of regulatory requirements.

8.2 *Minimum detectable activity*

The required minimum detectable activity (MDA) will depend on the particular application and be subject to local regulations and plant design; it shall be specified by the plant designer. The manufacturer shall specify the achievable minimum detectable activity for nuclides of interest, as a function of the ambient gamma background at the detector assembly, taking account of any provisions incorporated to provide an on-scale indication on the monitor.

8.3 *Effective range of measurement*

For assemblies with linear scales, the effective range of measurement shall be between 10% and 100% of each range.

For assemblies with a logarithmic scale, the effective range shall be between one-third of the least significant decade and full scale.

For assemblies with digital indication the effective range shall be from the start of the second least significant decade (i.e. two digits indicated) to the full range of indication available.

8.4 *Overload performance*

It will be necessary to set some upper limit to the dose (rate) or activity level for the purpose of design. Such limits should be agreed between manufacturer and purchaser. Within these limits, the detector and associated electronic processing unit shall, as far as practicable, be designed such that, when exposed to activity or dose (rate) beyond the measuring range, the indication does not decrease or fall to zero. Following such exposure beyond the measuring range, the detector and its electronic processing unit shall recover within the constraint of the electronic time constants.

9 Indication characteristics

9.1 *Scale graduation*

The reading scale shall be graduated in units appropriate to the measurement technique and the indication shall be of activities or doses (rates). In the absence of an unambiguous calibration in terms of such quantities, additional indication in units of directly measured quantities (e.g. amperes or counts per second) shall also be provided.

9.2 *Type of display*

The choice between logarithmic and linear scales or digital displays shall be appropriate to the purpose of the equipment. Logarithmic scales or digital displays are generally preferred and linear scales are not recommended unless there is a specially identified reason for their use.

In the case of assemblies provided with essentially linear scales, it shall be possible to change the range of measurement in such a way that the scaling factors do not exceed 10.

In cases where the accident conditions are such as to give rise to large variations in reading, manual switching between ranges shall not be used except by special agreement.

In the case of automatic change of scale, an indication of the scale in use shall be provided.

10 Reliability

All equipment shall be designed to an appropriate standard of reliability taking account of the defined duty and any redundancy requirements (e.g. equipment connected to a reactor protection system would be of commensurate reliability to the rest of that system).

Satisfactory evidence shall be provided that, subject to appropriate planned maintenance, the equipment has a mean time between failures (MTBF) of at least 20 000 h. Under normal conditions, where the basis of the MTBF figure is a theoretical assessment, the basic data used and the method of assessment shall be agreed between manufacturer and purchaser.

Additionally, the equipment shall be designed to survive the specified accident conditions and operate satisfactorily for at least 100 days after the accident, unless otherwise specified by the plant designer. The designer may, for example, specify variations in the survival time either because of the requirements of his safety case or because the accessibility of the equipment is such that repair is possible.

The manufacturer shall specify the periods between the necessary routine maintenance operations and fully describe each maintenance procedure. These maintenance requirements shall be kept to the minimum practicable.

The equipment shall be designed as far as practicable to be "fail safe", for example, so that interruption of power supplies or component failure causing loss of indication will result in actuation of a failure alarm.

11 Fluid flow characteristics

Where an accident monitor includes a fluid flow system as part of its design, the following requirements shall be satisfied.

11.1 *Pump*

Where a pump is an integral part of any assembly, the following requirements shall be met.

11.1.1 *Pump location*

If there is any possibility of the activity of interest depositing in the pump, it shall be placed downstream from any filter or measuring unit.

11.1.2 *Pump maintenance*

The pump shall be capable of continuous operation between scheduled maintenance operations and under foreseen accident conditions. The frequency of maintenance operations shall be agreed between the manufacturer and the purchaser, but generally shall not be more frequent than once every three months. The design shall provide for ease of access to the pump and its replaceable parts. The use of peristaltic pumps or pumps fitted with commutator electric motors is not recommended.

11.1.3 *Pump safety devices*

The pump shall be fitted with necessary pressure and temperature safety devices to protect it against any abnormal temperature or pressure increase. The operation of any such safety device shall be indicated to the user by a suitable alarm.

11.1.4 *Type of pump*

Where the measurement technique is sensitive to flow-rate, the pump shall be of the constant displacement type or an active flow control system shall be included so that variations in pressure drop in the system do not have a significant effect on the flow-rate.

11.2 *Flow control*

11.2.1 *Equipment sensitive to flow-rate*

If a constant displacement pump is not fitted, a flow-rate control device shall be provided which has a flow-rate adjustment range sufficient to allow for variations in the intrinsic characteristics of the pump and any filters used.

11.2.2 *Equipment not sensitive to flow-rate*

Equipment which requires a flow, but for which the flow value is not critical, shall be fitted with sufficient flow control facilities to maintain the flow between limits defined as adequate for the purpose of the measurement.

11.3 *Flow measurement*

A flow-rate meter of the direct reading type shall be provided and suitable flow alarms shall be provided for warning of any excessive variation of flow. The flow-rate shall be measured after a filter unit. The measurement shall be expressed in appropriate SI units of volume per unit time and the conditions at which the measurement is made shall be clearly indicated.

12 **Alarms**

The alarm and indication facilities shall be appropriate to the purpose of the equipment as specified by the plant designer. However, in the absence of any specification to the contrary, the following shall be provided.

High level, low level and grouped fault alarm circuits shall give separate local visual indication on the control and measurement assembly. Audible alarms may be provided in addition. These alarm circuits shall also operate two sets of changeover contacts (which may be common for low level and fault alarms) for use with external alarms. The alarm contacts and connections shall be suitable for use at up to 260 V (or 130 V for equipment utilizing 110 V supply) a.c./d.c. Contact materials shall be appropriate for expected loads and operating voltages.

As far as practicable, alarm functions shall be provided with test facilities to allow checking of alarm operation. In the case of adjustable alarms, checking shall be possible over the range of adjustment, with indication of the actual alarm operation point.

Alarm circuits shall be operable either to hold an alarm condition until specifically reset to zero by a reset control or to auto-reset when the alarm state disappears. The two modes of operation shall be available by simple modification on all equipment.

12.1 *High level alarms*

At least one adjustable alarm set point shall be provided, adjustable over at least 10% to 90% of scale reading (linear scales), from 50% of the lowest decade to 90% of the highest decade (logarithmic scales), or from 10% of the second least significant decade to 90% of the highest decade (digital display).

12.2 *Low level alarms*

An alarm shall be operable over the lowest 10% of scale reading (linear scale) or over the whole of the lowest decade (logarithmic scales or digital display), which may form part of a failure alarm system by indicating loss of background count rate. A radioactive source shall be incorporated in the equipment if necessary to give a normal reading above this alarm level.

12.3 *Fault alarms*

The following alarms shall be provided:

a) An alarm that indicates as many electronic circuit or mechanical system faults as possible. Wherever reasonably practicable, separate indication of the source of the fault shall be given.

b) An alarm to indicate loss of essential service (e.g. detector coolant flow) or a low level in an essential coolant reservoir.

13 Indication facilities

In addition to the visual display of the measured value, operational indication shall be provided on the equipment, together with appropriate outputs to allow indication elsewhere in the plant for the following :

- power on;
- pump on, if appropriate;
- coolant flow and/or reservoir level for the detector cooling system, if appropriate;
- equipment in fault-free conditions (no fault alarm operated);
- occurrence of power supply changeover.

Where fluids flow through the equipment, then appropriate flow-rate indication shall be provided.

An output shall be provided permitting remote indication and capable of interfacing to specified external devices (e.g. indicating meter, indicating recorder, magnetic tape recorder, printer, computer system, radio telemetry system).

14 Provisions for operational testing

Provisions shall be made to allow the user to carry out a periodic check of the satisfactory operation of the assembly, including calibrations and scale linearity. These provisions shall normally allow the checks to be carried out from the control and measurement assembly.

It shall be possible to check the calibration of the assembly at two representative points on the measurement range. For example, in the case of a logarithmically scaled assembly, at approximately 25% and 75% of scale angular deflection. This check shall be carried out using a suitable radioactive source in order to check at least one point. The second calibration point may be checked electronically.

15 Provisions for commissioning and maintenance

All electronic equipment shall be provided with sufficient easily accessible identified test points to facilitate setting up and fault location, together with, where necessary, maintenance aids such as extension printed wiring boards and jumper leads. Any special maintenance tools and a satisfactory maintenance manual shall be supplied.

The design of all equipment shall be such as to facilitate ease or repair and maintenance.

16 Detection assembly (or sampling and detection assembly)

The assembly includes one or more radiation detectors and, in the case of fluid activity monitors, one or more of the following sub-assemblies and functional units :

- sampling and exhaust pipes;
- delay devices for decay of short-lived potentially interfering nuclides;
- facilities for drawing samples for laboratory analysis;
- facilities for the control of solid check sources;
- facilities for tests with active gases or liquids or equivalent solid sources;
- detector cooling devices;
- sample cell;
- aerosol retention device;
- device for moving the filter ;
- ambient gamma radiation protection devices;
- flow-rate monitoring and control devices;
- pump.

The detection assembly or the sampling and detection assembly shall be constructed in such a manner that the build-up of contamination is reduced as much as possible and shall be designed to facilitate decontamination when this becomes necessary. External surfaces shall be specially treated to permit decontamination.

Under some circumstances, a fluid stream may contain an explosive mixture of gases. Where this may occur, the assembly shall be designed to prevent the possibility of ignition of the stream by the instrumentation. The fluid stream may also contain noxious and corrosive chemical material, and special arrangements will be required to protect measuring systems.

Where detector cooling or other services have to be provided from a local reservoir, these shall not require service attention or recharging more frequently than every eight days.

Where appropriate, the design of the activity retention assembly shall be such as to minimize by-passing of the collecting medium.

17 Control and measurement assembly

The control and measurement assembly includes essentially the following parts:

- electrical control and power supply sub-assemblies;
- electronic measuring sub-assemblies;
- measurement display unit;
- warning signals and alarm units.

The assembly may be associated with a central radiation display and/or control panel. In this case it shall be capable of being installed in electronic racks of standard dimensions.

18 Ambient gamma radiation protection devices

These devices may be provided in order to reduce the effect of the ambient gamma radiation on the measurement. They are of two types:

- shielding devices;
- electronic devices.

Either or both types of protection device may be incorporated, as appropriate to the overall system design.

It may be agreed between the manufacturer and the purchaser that significant background radiation is only to be expected from defined directions or sources (vessels, pipes, etc.). In such cases, the construction of shielding may take this into account. In the absence of such agreement, shielding shall give a virtually identical radiation attenuation in all directions seen from the sensitive volume of the detector, taking into account the structural materials of the detection assembly, and the angular response of the detector.

If the equipment cannot easily be removed from the shielding, such shielding shall be easily removable, and shall therefore be constructed of juxtaposable and overlapping elements having a mass of 15 kg or less, unless otherwise agreed between manufacturer and purchaser.

When electronic techniques incorporating additional detectors are used to reduce the effect of background, these detectors shall be chosen and located to give the best practicable compensation, taking account of the range of gamma energies and the direction of the radiation.

19 Acoustic noise level of the assembly

The acoustic noise level of the assembly mainly arises from a sampling and detection sub-assembly and more particularly from the operation of a fluid duct system and the resultant vibration.

The manufacturer shall select the components and shall design the assembly so that the acoustic noise level is minimized and consistent with the type of environment for which the assembly is intended. Noise levels shall be specified in accordance with appropriate ISO standards (e.g. ISO 532 and 1999) .

20 Electrical interference

All necessary precautions shall be taken against the effects of electrical interference. In the absence of other requirements, the equipment shall comply with IEC 801-1.

CHAPTER III: TEST PROCEDURES

21 General test procedures

General test procedures applicable to all types of accident monitors are covered in this standard. Except where otherwise specified, these are to be considered as "type tests", although any or all may be considered as "acceptance tests" by agreement between manufacturer and purchaser. The stated requirements are, in general, minimum requirements and may be extended for any particular equipment or function.

Detailed test procedures will vary in accordance with the particular characteristics of each type of monitor and specialized test requirements are given in the appropriate standards dealing with each type of accident monitor.

Standard test conditions are defined in Table I.

The tests described in this standard may be classified according to whether they are performed under standard test conditions or under other conditions.

22 Tests performed under standard test conditions

Tests which are performed under standard test conditions are listed in Table II which indicates, for each characteristic under test, the requirements according to the sub-clause where the corresponding test method is described.

23 Tests performed with variation of influence quantities

The object of these tests is to determine the effects of variations of the influence quantities. In order to facilitate the execution of these tests, they are grouped into two categories :

- tests relating to the fluid circuit (where applicable);
- tests relating to the measurement, alarm and indication devices.

These two categories of tests are carried out independently of each other. The tests relating to the measurement, alarm and indication units are shown in Table III with the range of variation of each influence quantity and the limits of the corresponding variations of the indication of the assembly. The tests of the fluid circuit are shown in Table IV with the range of variation of each influence quantity and the limits of the corresponding variations of the parameters under test.

In order to check the effects of the variation of each influence quantity listed in Tables III and IV, all the other influence quantities shall be maintained within the limits of the standard test conditions given in Table I, unless there are other requirements.

In order to simplify these tests, for each individual influence quantity, only a single type test need be performed. This test shall measure the effect of the specified change of influence quantity for dose (rate) or activity levels of approximately 50% of any one range or decade, except the most sensitive range or decade.

It shall be noted that, if an electronic method of compensation against ambient background radiation is included in the equipment, all tests of the measuring assembly shall be performed with the compensation circuits in operation and adjusted according to the manufacturer's instructions.

24 Statistical fluctuations

For any test involving the use of radiation, if the magnitude of the statistical fluctuations of the indication, arising from the random nature of radiation alone, is a significant fraction of the variation of the indication permitted in the test, then sufficient readings shall be taken to ensure that the mean value of such readings may be estimated with sufficient precision to demonstrate compliance with the test in question. The interval between such readings shall be at least three times the response time in order to ensure that the readings are statistically independent.

This requirement may not apply to digital instruments (see 3.11).

25 Performance characteristics

25.1 *Reference response*

25.1.1 *Requirements*

The manufacturer shall state the relationship between the indication given by the measuring assembly and the reference dose (rate) or activity when the equipment is operated under standard test conditions (Table I) and set up as defined by the manufacturer.

25.1.2 *Test method*

The assembly shall be operated under standard test conditions and set up as defined by the manufacturer with no reference radiation source present.

The background indication shall be noted. The assembly shall then be "exposed" to an appropriate reference source sufficient to give a reading approximately at the mid point of the scale or decade above the lowest scale or decade.

The value of R_{ref} shall be computed as defined in 3.13.

25.2 *Accuracy of response to appropriate dose (rate) or activity*

The requirements and specified tests relate to equipment performance using appropriate prepared test sources which shall be related to the actual dose (rates) or activities to be measured. Standards of accuracy of relationship of test sources to dose (rate) or activity quantities may vary with monitor application.

Unless otherwise specified, the standard of preparation of test sources used in the required tests shall, however, be such that the uncertainty in the conventionally true activity or dose rate from each source in absolute terms (ε_{SA}) is better than 10% and the uncertainty in the conventionally true activity (or dose rate) between sources of the same test set (ε_{SR}) is better than 5%. The test sources shall be traceable to a recognized standards laboratory.

25.2.1 *Requirements*

Under standard test conditions, with the calibration controls adjusted according to the manufacturer's instructions, the relative intrinsic error shall not exceed the value given in Table II over the whole of the effective range of measurement as specified in 8.3.

25.2.2 *Test source activity*

The test shall be performed with sources of activity appropriate to the equipment concerned.

More than one reference activity source will be required in order to cover the effective range of measurement.

The relative activities of the sources used shall be such that, except where electronic tests have been agreed, an appropriate indication is obtained in each range (for assemblies with linear scales) or each decade (for assemblies with logarithmic scales or digital display).

25.2.3 *Tests to be carried out*

A type test shall be carried out on at least one assembly of the series and one routine test shall be performed on each assembly.

25.2.4 *Test method*

A certain number of radiation tests are required to meet both type test and routine test requirements. These are specified below. The remaining test requirements may be carried out using radiation, but, in order to limit the number of sources required, these tests may be carried out electronically. In the latter case, the assembly may be tested by injection of suitable electronic signals into the normal input point of the assembly. The value of the injected signals shall be known to the same accuracy as defined for the test sources.

A. *Type test*

For assemblies with essentially linear scales, the source test shall be performed on at least one point on each range at about 25% of the lowest range, 75% of the highest range and about 50% of the other ranges. By agreement between manufacturer and purchaser, electronic tests may be substituted for intermediate ranges. Source or electronic tests shall be carried out at about 25%, 50% and 75% of each range.

For assemblies with non-linear scales, or digital display, the source test shall be performed on at least one point, at approximately the mid point of each decade except the highest where the test should be at about 75%. By agreement between manufacturer and purchaser, electronic tests may be substituted for intermediate ranges or decades. Source or electronic tests shall be carried out at 25%, 50% and 75% of each decade.

B. *Routine test*

For assemblies with linear scales, a source test shall be performed on at least one point on one range at about 50% of full-scale deflection. Source tests or equivalent electronic tests shall be performed for corresponding values on all other ranges.

For assemblies with non-linear scales, or digital display, a source test shall be performed at about the mid point of at least one decade. Source tests or equivalent electronic tests shall be performed at about the mid point of all the other decades.

25.2.5 *Expression of results*

The results of the tests shall be expressed as the relative intrinsic error, E, expressed as a percentage, given by the relationship:

$$E = \frac{A_i - A_t}{A_t} 100\%$$

where :
A_i = indicated activity or dose (rate) level
A_t = conventionally true activity or dose (rate) level

The requirements of 25.2.1 may be considered to be met if:

a) the difference between any of the observed values of E does not exceed $2(E_i + \varepsilon_{SR})$ and

b) no single observed value of E exceeds $(E_i + \varepsilon_{SA})$

where:
E_i = required accuracy of indication (relative intrinsic error) (%) given in Table II
ε_{SA} = absolute uncertainty of conventionally true dose (rate) or activity of the test source (%)
ε_{SR} = relative uncertainty of the test dose (rate) or source to other dose (rate) or sources in the test set (%)

25.3 *Response to ambient gamma radiation*

25.3.1 *Requirements*

There is generally a relationship between the response to ambient gamma radiation and the minimum detectable activity, and the requirement for both depends on the particular plant application. The response of the assembly to ambient gamma radiation, as well as the minimum detectable dose (rate) or activity, shall be agreed between manufacturer and purchaser.

The manufacturer shall state the minimum detectable dose (rate) or activity (as defined in 3.6) under standard test conditions. The manufacturer shall also state minimum detectable dose (rate) or activity and the maximum value of the reading [apparent dose (rate) or activity] of the measurement assembly, when the detector, fitted with its ambient gamma radiation protection devices, is exposed in a geometry specified by the manufacturer to an external gamma dose rate due to ^{137}Cs. Unless otherwise agreed between manufacturer and purchaser, the response to gamma exposure from any other direction and of any gamma energy up to 1.3 MeV (^{60}Co) shall not exceed twice the maximum reading value specified (above). The test dose rate shall be appropriate to the function of the accident monitor and be agreed between manufacturer and purchaser.

25.3.2 *Test method*

The equipment shall be operated under standard test conditions with no radioactive source present and the "background" indication shall be determined. The minimum detectable activity shall be computed and shall conform to the manufacturer's specifications.

Next, using a ^{137}Cs source, the source shall be positioned relative to the detector so that the source to detector distance is at least 2 m and the conventionally true absorbed dose rate in air at the detector position, with the assembly absent, is equal to the test dose rate. The orientation of the equipment with respect to the direction of radiation from the source shall be as specified by the manufacturer. Under these conditions, the reading of the measuring assembly shall not exceed the value specified.

The detector shall also be exposed in a number of other sources to detector orientations, as agreed between manufacturer and purchaser. The reading of the measurement assembly in each case shall not exceed the value specified.

Using alternative gamma radiation sources, agreed between manufacturer and purchaser, the ^{137}Cs source test above shall be repeated, with the reference source to detector orientation. The reading of the measurement assembly shall not exceed the value specified.

25.4 *Effect of other radiations*

When the assembly is used for measuring one type of radiation, other activities present, for example neutrons and/or high energy betas, may affect the reading. The extent to which this effect is present and is acceptable will depend on the application and the configuration of the assembly. Additional requirements are specified in those parts of this standard dealing with particular types of monitors.

25.5 *Overload*

25.5.1 *Requirements*

The equipment shall continue to indicate the maximum scale reading and all high level alarms shall remain "tripped" when the equipment is "exposed" to an activity level or dose (rate) above the measuring range. When the high "exposure" level is removed the equipment shall return to normal indication as rapidly as possible (within the constraints of electronic time constants) and, further, shall, within a reasonable period, operate in accordance with the specified requirements of the rest of this standard.

In the absence of otherwise agreed specifications, the following tests shall be carried out.

25.5.2 *Method of test*

a) Subject the detector assembly to an appropriate source of activity to give a reading at approximately 50% of the most sensitive range; note the reading.

b) Subject the detector assembly to an appropriate type of radiation source of activity ten times greater than that necessary to produce maximum scale reading, or sufficient to produce maximum scale reading if the plant designer agrees this cannot be exceeded. Maintain the exposure for at least 10 min and verify that the instrument maintains a maximum reading and high level alarms remain in a "tripped" state.

c) Remove the source of activity and after a period to be agreed between manufacturer and purchaser, but generally of no more than twice the time required for the indication to return effectively to zero, "expose" the detector assembly under identical conditions as in test a) above. The reading shall not differ by more than 10% from the value then noted in test a).

25.6 *Stability of indication*

25.6.1 *Requirements*

The indication from a given source of activity, after the assembly has been in operation 1 h, shall not vary in the next 500 h by more than 10% of maximum scale angular deflection for linear scaled instruments, 20% of the angular deflection equivalent to one decade for logarithmic scaled instruments, or, for digital display, 10% of indication.

25.6.2 *Test method*

Use a radioactive source to give a reading between one-third and one-half of scale maximum on the most sensitive range (linear scales), approximately two-thirds of the maximum of the least significant decade (logarithmic scales) or approximately at 20% of the maximum of the second least significant decade (digital display).

Take sufficient readings after 1 h, then further readings at about 10 h, 100 h, 200 h and 500 h with no adjustment made to the assembly. The means of the readings taken at each time shall lie within the limits indicated.

Readings shall be corrected for decay of the source if necessary.

26 **Electrical characteristics**

26.1 *Statistical fluctuations*

26.1.1 *Requirements*

Because of the random nature of radiation, the readings may fluctuate about a mean value. The coefficient of variation of the reading due to random fluctuations shall be less than the following values :

a) for linear scales: 10% for any dose (rate) or activity level exceeding that corresponding to one-third of the full scale on the most sensitive rang;

b) for logarithmic scales: 20% for any dose (rate) or activity level exceeding that corresponding to the maximum of the least significant decade of reading;

c) for digital display: 10% for any dose (rate) or activity level exceeding that corresponding to more than the minimum of the second least significant decade.

26.1.2 *Test method*

Use a radioactive source to give an indication between one-third and one-half of scale or range maximum on the most sensitive range (linear scale), or approximately at 20% of the maximum of the second least significant decade (logarithmic scale or digital display).

In accordance with clause 24, take sufficient readings of the indication of the assembly at convenient time intervals. Find the mean value and the coefficient of variation of all the readings taken. The coefficient of variation so determined shall lie within the limits of 26.1.1.

26.2 *Warm-up - Detection and measurement assembly*

26.2.1 *Requirements*

The maximum warm-up time required to reach standard performance conditions is indicated in Table I. Furthermore, the assembly shall, when exposed to the reference activity, give an indication which does not differ by more than ±10% from the value obtained under standard conditions within 30 min after being switched on.

> *NOTE* - This is not normally a critical parameter for installed equipment. If the plant design is such as to require a more rapid warm-up, this should be specified.

26.2.2 *Test method*

Prior to this test the equipment shall be disconnected from the power supply for at least 1 h. Use a radioactive source that will give approximately one-third to one-half of the maximum reading. Switch on the detection and measurement assembly.

Note values of indication every 5 min during 1 h. Ten hours after switching on, take sufficient readings, in accordance with clause 24, and use the mean value as "final value" of indication.

Draw a graph of indication with time, correcting for decay in activity as necessary.

The difference between "final value" and the value read from the curve for 30 min shall lie within the limits specified.

26.3 *Power supply*

If assemblies are designed to operate from a.c. power supplies, this shall be from single phase a.c. supply voltage in one of the following categories in accordance with IEC 293:

- series I: 220 V;
- series II: 120 V and/or 240 V.

By agreement between manufacturer and purchaser, three-phase supplies may be used for fluid pump motors.

> *NOTE* - Nominal single-phase power in North America and in a number of countries is 117 V and/or 234 V, 60 Hz. Nominal single-phase power of 110 V, 50 Hz is used in the United Kingdom in addition to 240 V. For equipment for use under these conditions, the appropriate nominal voltage should be chosen accordingly.

By agreement between manufacturer and purchaser, the equipment may be designed for operation from a low voltage standby supply in the case of a power failure. In such cases it would be desirable for the equipment not to malfunction or trigger an alarm as a result of the supply change-over.

26.4 *Power supply variations*

26.4.1 *Requirements*

The assemblies shall be capable of operating from the mains with a supply voltage tolerance of +10% and -20% and supply frequencies of 47 Hz to 51 Hz (57 Hz to 61 Hz where nominal frequency is 60 Hz) without the indication varying by more than 10% from the indication under standard test conditions.

26.4.2 *Test method*

Use a radioactive source to give a reading of approximately two-thirds of the full-scale deflection on the most sensitive range (linear scales) or approximately at 20% of the maximum of the second least significant decade (digital display) or approximately two-thirds of the maximum of the least significant decade (logarithmic scale). With the supply voltage and frequency at their nominal values, take the mean of a sufficient number of readings in accordance with clause 24.

Take the mean of two further sets of consecutive readings with the supply at nominal frequency and 10% above the nominal voltage and the mean of sufficient consecutive readings with the supply at nominal frequency and voltage 20% below the nominal value. These two mean values shall not differ from that obtained with the nominal supply voltage by more than ±10%.

Take the mean of sufficient consecutive readings with nominal supply voltage and frequency of 47 Hz and the mean of sufficient consecutive readings with nominal supply voltage and frequency of 51 Hz (57 Hz and 61 Hz where nominal frequency is 60 Hz). These two mean values shall not differ from that obtained with the nominal supply frequency by more than ±10%.

The above tests shall be repeated for an activity level or dose (rate) corresponding to approximately two-third of scale maximum on the least sensitive range or decade of the assembly.

26.5 *Power supply transient effects*

26.5.1 *Requirements*

The equipment shall withstand a short interruption in power supply of at least 10 ms duration without interruption of normal operation and without changing any alarm indications. The specification for the effect of longer interruptions in supply shall be agreed between manufacturer and purchaser.

The equipment shall be capable of withstanding randomly-phased transient over-voltage of either polarity on the power supply without damage and without the performance being out of specification. These transients may be either common-mode or series-mode and shall be assumed to reach the supply lines via an impedance of 50 Ω. Peak amplitudes are expressed as a percentage of the supply r.m.s. or d.c. voltage as follows (for the purpose of applying these values it may be assumed that the transients are half sine-wave and that the duration is measured at 50% of peak amplitude):

- amplitude 100% of supply voltage - duration 10 ms;
- amplitude 200% of supply voltage - duration 1 ms;
- amplitude 300% of supply voltage - duration 0.02 ms;
- amplitude 500% of supply voltage - duration 0.005 ms.

26.5.2 *Test method*

The mains supply input to the equipment under test shall be interrupted for a period of at least 10 ms. The equipment shall function and indicate correctly without interruption or resetting by the operator. The test shall be repeated ten times at random, covering all modes of operation. The output of digital assemblies shall be monitored throughout the test to ensure that no spurious operation occurs.

Randomly-phased transient pulses of half-sine waveform shall be injected into the mains input circuit, with the equipment in operation. The equipment shall be subjected to at least ten positive-going pulses, followed by a similar number of negative-going pulses applied at random, and selected to the requirements of the purchaser from the values quoted in 26.5.1. The equipment shall function and indicate correctly without interruption or resetting by the operator. The outputs of digital assemblies shall be monitored throughout the test to ensure that no spurious operation occurs.

26.6 *Alarm trip stability*

26.6.1 *Requirement*

This requirement excludes the detector.

Over a period of 500 h of operation, the operating point of any alarm circuit with a nominal set level shall not deviate outside the range 95% X to 105% X for linear ranged instruments and 80% X to 120% X for logarithmic ranged instruments.

26.6.2 *Test method*

For any alarm circuit whose nominal trip setting has been determined as X:

a) for a condition equivalent to 94% X or 79% X (whichever is appropriate) applied to the assembly electronically, no trip shall occur within 500 h;

b) when a condition equivalent to 106% X or 121% X (whichever is appropriate) is applied to the assembly, at 1 h, 10 h, 100 h, 200 h and 500 h after setting to operation, the alarm shall operate within the response time of the instrument.

26.7 *Alarm trip range*

26.7.1 *Requirement*

This requirement excludes the detector. The range of alarm settings shall conform to the requirements of clause 12.

26.7.2 *Test method*

This test shall be performed on each adjustable alarm unit. Using an appropriate electronic signal generator, as specified by the manufacturer, the range of indication of the equipment over which the alarm trip operates shall be determined.

For alarms intended to operate on increasing signals, the alarm shall be adjusted to its lowest setting and the input signal increased slowly until the alarm operates. The indication of the equipment shall be noted. The alarm shall then be re-adjusted to its highest setting and the input signal increased slowly until the alarm operates again. The indication of the equipment shall again be noted.

For alarms intended to operate on decreasing signals, carry out the same procedure as above, but slowly decreasing the level of input signal.

26.8 *Equipment failure alarms*

The low level alarm shall be tested according to the requirements of clause 12, in accordance with 26.7.

Other tests of failure alarms against appropriate equipment malfunctions shall be carried out by agreement between manufacturer and purchaser.

27 Environmental performance characteristics

The values referred to in these clauses generally apply to the alarm and indication assembly; they also apply to the detector assembly unless otherwise specified. However, more stringent conditions are likely to apply to the detection assembly and appropriate test conditions shall be agreed between manufacturer and purchaser to cover the appropriate accident and post-accident conditions.

> *NOTE* - Where equipment is to be mounted in an air-conditioned location (IEC 654-1, Class A), it may be agreed between manufacturer and purchaser to substitute temperature and humidity range values from that standard. However, caution is advised in making such a relaxation, bearing in mind the possibility of degradation in the performance of air-conditioning arrangements in accident/post-accident conditions.

27.1 *Ambient temperature*

27.1.1 *Requirements*

The indication shall remain within the limits specified in Table III over the range of temperatures in that table. It should be noted that for this type of equipment the detection and sampling assembly may have to operate under different environmental conditions from the measuring assembly. Part, or all, of the detection assembly may have to operate under more elevated temperature conditions than those quoted in Table III. Where this is the case, appropriate tests shall be agreed between manufacturer and purchaser.

> *NOTE* - Consideration of accident conditions may well identify the possibility of rapid increase in temperature at some equipment locations. Where this is the case, it would be appropriate for a test on the effect of this condition to be included in the agreed procedure, with the requirement that, unless otherwise agreed, there be less than 20% change in indication.

27.1.2 *Test method*

The detection assembly, if necessary without its shielding, shall be exposed to suitable test sources as in the routine test of 25.2.4, such that the nominal reading under standard test conditions is known.

This test shall normally be carried out in an environmental test chamber. It is not in general necessary to control the humidity of the air in the test chamber unless the equipment is particularly sensitive to changes of humidity.

The temperature shall be maintained at each of its extreme values for at least 4 h, or whatever longer period is necessary for the equipment to reach equilibrium temperature. The indication of the assembly shall be measured during the last 30 min of this period and compared with the reading under standard conditions.

Where a test of effect of rapid change of temperature has been agreed upon the following procedure may be adopted:

The assembly shall be placed in a controlled environment of 20 ± 2 °C and allowed to stabilize for a minimum of 60 min. The assembly shall be exposed in a reproducible geometry to an appropriate source of ionizing radiation of sufficient intensity to produce a response of approximately mid-scale or mid-decade on an appropriate scale or decade. The mean indication shall be determined. The assembly and radioactive source shall be removed from this environment and placed directly into an environmental chamber such that the same exposure geometry is established and the temperature near the assembly is the agreed high value ±2 °C. This procedure shall be performed in less than 2 min. The mean indication shall be determined then and every 15 min for 2 h.

After this period, the assembly and the radioactive source shall be removed from the environmental chamber and returned to the first environment such that the same exposure geometry is established and the temperature near the instrument is 20 ± 2 °C. This procedure shall be performed in less than 2 min. The mean instrument reading shall be determined then and every 15 min for 2 h.

27.2 *Relative humidity*

27.2.1 *Requirement*

The indication shall not vary by more than ±10% from the value obtained under standard test conditions.

27.2.2 *Test method*

The detection assembly shall be exposed to suitable test sources as in 25.2.

The test may be performed at a single temperature of 30 °C and humidity of 90%; permitted variation of ±10% in the indication as specified in Table III is in addition to the permitted variations due to temperature alone.

27.3 *Atmospheric pressure*

The influence of atmospheric pressure is, in general, significant only for an unsealed detector utilizing a gas as the detecting medium. In this case, the atmospheric pressure at which all tests are carried out shall be stated, and the effects of variations in atmospheric pressure shall be indicated.

Representative tests at other atmospheric pressures may be performed if required.

27.4 *Sealing*

In cases where the assembly is likely to be used in exceptionally damp conditions (for example outdoor, etc.), the purchaser shall state his requirements regarding protection against dampness. The assembly shall then satisfy the requirements of IEC 68, or otherwise form the subject of an agreement between manufacturer and purchaser.

28 **Fluid circuit characteristics**

These tests are intended to be applied, by agreement between manufacturer and purchaser, to all equipment for which the response is dependent on constant flow-rate through a sampling and detection assembly.

When the equipment is insensitive to flow-rate, but nevertheless requires a sampling flow in order to function, a simple test of the flow circuit and any flow alarms shall be agreed between manufacturer and purchaser.

When the equipment is sensitive to flow-rate, but the flow-rate has to vary in step with the effluent or process stream flow-rate, appropriate tests shall be agreed between manufacturer and purchaser.

The requirements of these tests are summarized in Table IV.

28.1 *Flow-rate stability*

The aim of this test is to determine the sampling flow-rate under standard test conditions, with the pressure drop due exclusively to the fluid circuit and any inlet or sampling filter (clean filter).

28.1.1 *Requirement*

The manufacturer shall specify the nominal flow-rate for the type of filter which is used. After the normal warm-up time of the sampling assembly (1 h) , the measured flow-rate shall not deviate by more than ±10% from the nominal flow-rate.

28.1.2 *Test method*

For this test a volumetric measuring device or flowmeter, standardized under the measuring conditions and having a precision better than 3%, is incorporated in the fluid circuit at the inlet to the equipment. The equipment shall be switched on and the flow measured after about 1 h, 5 h, 20 h and 100 h. The readings shall not deviate by more than 10% from the rated flow. In order to eliminate problems of increasing filter pressure drop, it may be necessary to draw the fluid from a particle-free source.

28.2 *Effects of filter pressure drop*

Since the nature of the filter and the degree of blockage may differ from one test to another, only measurements of overall pressure drop and flow-rate will be considered.

28.2.1 *Requirements*

The test shall establish the increase in pressure drop causing a 10% decrease from the nominal flow under standard conditions.

The acceptable minimum pressure drop, liable to cause a 10% decrease from the nominal flow, shall be agreed between manufacturer and purchaser.

28.2.2 *Test method*

For this test, a calibrated pressure gauge shall be fitted downstream of the filter, at the point intended by the manufacturer, in order to measure the pressure drop due to the fluid flow. This instrumentation (U-tube, differential manometer, etc.) shall provide a direct indication of the pressure drop obtained by inserting a variable restrictor (e.g. a valve) between the flowmeter and the assembly.

The flow measurements shall be carried out as specified in 28.1, the variable restrictor being adjusted to give a mean flow 10% below the nominal flow under standard test conditions.

The measured pressure drop under these conditions shall be not less than the agreed value.

28.3 *Effects of power supply voltage*

28.3.1 *Requirement*

The flow-rate shall not vary by more than 5% when the power supply voltage varies between +10% and -20% of the nominal supply voltage.

28.3.2 *Test method*

For this test, the sampling and detection assembly is connected to a power supply of nominal frequency with a voltage which is variable from +10% to -20% of nominal value.

The measurement of the flow-rate shall be carried out as specified in 28.1.2 and the readings noted at nominal voltage and the extremes of the voltage range.

28.4 *Effects of power supply frequency*

28.4.1 *Requirement*

The flow-rate shall not vary by more than 10% when the frequency varies from 47 Hz to 51 Hz (57 Hz to 61 Hz when nominal frequency is 60 Hz).

28.4.2 *Test method*

For this test, the sampling and detection assembly is connected to a power supply of the nominal voltage and a frequency which may be varied between 47 Hz and 51 Hz (alternative values 57 Hz and 61 Hz).

The flow-rate shall be noted at nominal frequency and at the quoted frequency limits.

29 **Qualification**

The equipment may require to be qualified in accordance with the requirements of IEC 780. The extent of such qualification will depend on the equipment function as established for the plant design and shall be agreed between manufacturer and purchaser. No specific test requirements are given, but if such tests are required these shall be specified and carried out in accordance with the agreed qualification requirements (for example, equipment associated with the reactor protection system would be tested against the requirements of the IEC standard for such equipment).

CHAPTER IV: DOCUMENTATION

30 Type test report

The manufacturer shall make available, at the request of the purchaser, a report on the type tests carried out to the requirements of this standard.

31 Certificate

A certificate shall be provided with each equipment, giving at least the following general information and the additional information specified in the relevant subsequent part of the standard :

- manufacturer's name or registered trade mark;
- type and serial number of the equipment and assemblies;
- type of detector;
- effective range of measurement;
- background indication under standard test condition;
- scale limits for each measuring range;
- scale graduation;
- response to specified test sources;
- response to ambient gamma radiation;
- maximum permissible cable length between units;
- nominal flow of the fluid being monitored through the equipment (where applicable).

32 Operation and maintenance manual

Each assembly shall be supplied with an appropriate instruction manual and log book in accordance with IEC 278.

33 Additional documentation

Appropriate design documentation and manufacturing records shall be provided in accordance with the requirements of the quality assurance procedure applicable to the plant.

These may include :

- sources of design input;
- detail of development of requirements;
- design drawings and diagrams;
- test records;
- calibration records;
- non-conformity reports;
- seismic and environmental qualification test procedures and results.

TABLE I

Reference conditions and standard test conditions

(*Unless otherwise indicated by the manufacturer*)

Influence quantity	Reference conditions	Standard test conditions
Reference radioactive source	As appropriate	As appropriate
Warm-up time (whole equipment)	60 min	>60 min
Ambient temperature	20 °C	18 °C to 22 °C
Relative humidity	65%	50% to 75%
Atmospheric pressure	101.3 kPa	86 kPa to 106 kPa *
Power supply voltage	Nominal supply voltage U_N	Nominal supply voltage U_N ±1%
Power supply frequency	Nominal frequency	Nominal frequency ±0.5%
Power supply waveform (for a.c. only)	Sinusoidal	Sinusoidal with total harmonic distortion lower than 5%
Gamma radiation background	Absorbed dose rate in air of 0.20 $\mu Gy.h^{-1}$ (20 $\mu rad.h^{-1}$)	Less than absorbed dose rate in air of 0.25 $\mu Gy.h^{-1}$ (25 $\mu rad.h^{-1}$)
Electromagnetic field of external origin	Negligible	Less than the lowest value that causes interference
Magnetic induction of external origin	Negligible	Less than twice the value of the induction due to the earth's magnetic field
Assembly controls	Set for normal operation	Set for normal operation
Contamination by radioactive elements	Negligible	Negligible

* Where the detection technique is particularly sensitive to variation in atmospheric pressure, the conditions shall be limited to ±5% of the reference pressure.

TABLE II

Tests performed under standard test conditions

Characteristics under test	Requirements	Reference (sub-clause)
Reference response	In accordance with the manufacturer's specifications	25.1
Relative intrinstic error (E_i)	Either - less than ±20% (any type of display) or - less than ±5% of the activity corresponding to maximum indication on appropriate scale (linear or digital display) whichever is least restrictive	25.2
Overload	To remain at full-scale indication when exposed to an activity ten times that which would give full-scale deflection *	25.5
Statistical fluctuations	Coefficient of variation less than 10%	26.1
Stability of indication	Less than 10% of the full-scale angular deflection on all ranges for linear scaled instruments. Less than 20% of the angular deflection equivalent to one decade for logarithmic scaled instruments. Less than 10% of indication for digital display (all over 500 h)	25.6
Alarm trip stability	Less than 20% of set point level over a period of 500 h	26.6
Alarm trip range	In accordance with clause 12	26.7
Equipment failure alarms	Low level alarm in accordance with clause 12. Other alarms by agreement between manufacturer and purchaser	26.8

* This requirement may be varied if agreed between manufacturer and purchaser (see 25.5.2).

TABLE III

Tests performed with variation of influence quantities

Influence quantity	Range of variation of influence quantity	Limits of variation of indication	Reference (sub-clause)
External gamma radiation from a ^{137}Cs source in defined source/detector geometry	Absorbed dose rate in air appropriate to equipment function	In accordance with the manufacturer's specifications	25.4
External gamma radiation from a ^{137}Cs source in other geometries	Absorbed dose rate in air appropriate to equipment function	As specified, but normally less than twice that obtained under reference conditions	25.4
External gamma radiation from other sources in the defined source/detector geometry	Absorbed dose rate in air appropriate to equipment function	As specified, but normally less than twice that obtained under reference conditions	25.4
Warm-up time	<30 min	±10% 1)	26.2
Power supply voltage	80% U_N to 110% U_N (U_N = nominal supply voltage)	±10% 1)	26.4
Power supply frequency	47 Hz to 51 Hz 2)	±10% 1)	26.4
Power supply transient effects	In accordance with 26.5	In accordance with 26.5	26.5
Ambient temperature 3)	Indoor use : 5 °C to 55 °C	±10% 1)	27.1
	Outdoor use : -10 °C to 40 °C	±20% 1)	
	-25 °C to 50 °C	±50% 1)	
Relative humidity	Up to 90% at 30 °C	±10% 1)	27.2
Atmospheric pressure	4)	4)	27.3
Electromagnetic field and magnetic induction of external origin	4)	4)	

1) Of the indication under standard test conditions.

2) 57 Hz to 61 Hz for countries where nominal frequency is 60 Hz.

3) Assemblies intended for temperate climates. In hotter or colder climates other limits may be specified. Additional requirements may exist for some equipment (see clause 27).

4) No general specification. Range of value of influence quantity and limits of variation of indication to be specified if required.

NOTE - For assemblies having a non-linear scale, a linear instrument can be substituted for the indicating meter of the assembly to verify the performance called for by this table.

TABLE IV

Tests of fluid circuit

(These tests are applicable only to assemblies whose response is dependent on flow-rate)

Influence quantity	Range of variation of influence quantity	Limits of variation of nominal flow-rate	Reference (sub-clause)
Time	1 h to 100 h	±10%	28.1
Filter pressure drop	In accordance with manufacturer's specifications	-10%	28.2
Power supply voltage	From 80% U_N to 110% U_N	±5%	28.3
Power supply frequency	From 47 Hz to 51 Hz *	±10%	28.4

* From 57 Hz to 61 Hz for countries where nominal frequency is 60 Hz.

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This Indian Standard has been developed from Doc : No. LTD 26 (1411).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Printed at New India Printing Press, Khurja, India